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High Resolution Interferometry of Localized Small Signal Gain in Yttrium X-ray Lasers*

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Predicted average gains of collisionally-pumped, neon-like x-ray lasers have always been 1.5 - 2 times the observed value. One possible source of uncertainty has been the atomic kinetics codes used to predict the small signal gain that is amplified. Another mystery has been the observed persistent lack of spatial coherence from x-ray laser targets. We have simultaneously measured small signal gain and electron density of a 2-mm-long yttrium x-ray laser plasma employed as an amplifier for a separately-produced yttrium x-ray laser. The plasma was viewed end-on with ~ 2 μm resolution. Measured small signal gains were found to be between 10 and 15 cm^{-1}, in agreement with predictions. This indicates that signal loss due to refraction is greater than calculated. More importantly, images showed that high gain was produced irregularly in spots with dimensions of ~ 10 μm. We suspect that this localization is caused by intensity variations in the optical drive laser, but it is uncertain whether the small regions are due to a developed plasma instability. The fact that much of the laser gain is produced in small regions explains why coherence is much less than expected.

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